Issued December 22, 1908.

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—Circular 156.

GIFFORD PINCHOT, Forester.

(IN COOPERATION WITH THE BUREAU OF PLANT INDUSTRY, B. T. GALLOWAY, CHIEF.)

PRELIMINARY REPORT ON GRAZING EXPERIMENTS IN A COYOTE-PROOF PASTURE.

By

JAMES T. JARDINE, Special Agent, Forest Service,

With an introduction by

FREDERICK V. COVILLE, Botanist, Bureau of Plant Industry.

[Cir. 156]

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1909

The information contained in this circular was gathered in the course of a series of experiments which are being carried on by the Forest Service and the Bureau of Plant Industry, acting in cooperation, to devise the best methods of enlarging the forage value of the grazing lands included in the National Forests. The grazing capacity of much of this area had been seriously depleted under the practice of unrestricted grazing before the lands came under direct governmental jurisdiction. Since that time it is estimated that the efficiency of Forest range lands has been increased 30 per cent through the regulations which provide for their orderly occupancy and the prevention of excessive grazing. But the lands have not yet been brought nearly to the point of their possible capability, nor even restored to their original productivity. The task of improving them to the state where they will support the largest number of live stock with the least waste is one of great importance, and one that will require time and careful study. The Forest Service in the prosecution of this undertaking obtained the assistance of the Bureau of Plant Industry along lines in which that Bureau had expert knowledge. Mr. Frederick V. Coville, Botanist of the Department of Agriculture, who has made a long and detailed study of grasses and grazing technique, assumed the direction of a series of experiments connected with those subjects in cooperation with the Branch of Grazing of the Forest Service. These experiments cover trials of the artificial reseeding of portions of the grazing lands with cultivated grasses, studies to ascertain how overgrazed areas can be reseeded naturally, and tests of schemes to increase the carrying capacity of the range by modifications in the existing system of handling stock.

The present circular is a progress report of work in the last-named direction, and describes an experimental coyote-proof sheep pasture, planned by Mr. Coville, which was undertaken to demonstrate the effect on forage that would result from rendering the herds immune from all disturbance by animal marauders.

GIFFORD PINCHOT.

CONTENTS.

ILLUSTRATIONS.

PRELIMINARY REPORT ON GRAZING EXPERIMENTS IN A COYOTE-PROOF PASTURE.

By James T. Jardine.

INTRODUCTION.

By Frederick V. Coville.

Under the herding system now used for the handling of sheep on the grazing lands of the National Forests a large amount of forage is wasted by trampling. The extent of the waste varies greatly with the character of the vegetation and the skill of the herder. A band of sheep driven rapidly over a range covered with succulent herbaceous plants, known to stockmen as "weeds," may trample and waste quite as much of the vegetation as they eat. One sheep owner of long experience insists that he has seen sheep so badly handled on a weed range that fully two-thirds of the carrying capacity of the land was wasted. On a grass range in open country, when the sheep are allowed to spread out and graze slowly over a wide area under the eye of the herder, much better results are obtained. Especially to be commended is the plan, as yet rarely practiced, by which the herder, instead of denuding a large area by driving his sheep for weeks to and from a single camp and bed ground, beds his sheep upon the range wherever they finish the day's grazing, and sleeps beside them. Such improved methods are rendered practicable on certain kinds of ranges, under their administration as National Forests, where the old competition of rival bands of sheep racing with each other to secure and hold possession of the choicest grazing areas is a thing of the past. In most of the Forests each owner is assigned a particular area, and is protected in its use and occupancy during the entire grazing season.

Notwithstanding the improvement already effected by the Forest Service, through its permit system, in reducing the unnecessary waste in the use of grazing lands, their carrying capacity is still far short of what it should be. A large loss of vegetation by trampling is inherent in the herding system itself. Even with the best herders it is impossible to handle large bands of sheep with the same grazing efficiency as is secured in the fenced pastures of the eastern United States, and when one considers the large percentage of herders who are not skilled or who have a greater regard for their own comfort than for the interests of the owner of the sheep or for the permanent welfare of the range, the aggregate waste must be regarded as a matter of serious public concern. That one-third of the vegetation on the sheep ranges in the National Forests is destroyed by trampling

is regarded as a conservative estimate. The number of mature sheep for which permits were issued in 1907 was 6,574,396. They occupied the National Forest range for an average period of four and one-fourth months. It is estimated that the gross income of sheep owners last year from the grass in the National Forests was $7,225,000, and that the grass trampled and wasted represents a possible additional gross income of about $3,500,000. It is worth while to ascertain what part of this loss can be obviated by substituting a pasture system, similar to the highly successful paddock system of Australia, for the present herding system.

The method of handling sheep now practiced in the arid-land States was developed under the public lands free-range system. Any stock owner had the right to graze his stock on any portion of the unreserved public lands. Two conditions rendered it impossible to handle sheep on the free range under the fenced-pasture system of the Eastern States. First, the public lands could not legally be fenced; second, the country was infested with wild animals, which killed the sheep when the herds were left to themselves. Within the National Forests there is no legal prohibition of the construction of fences; they may be built if needed. Wild animals, however, are still sufficiently numerous in sheep-grazing areas to be a serious menace to loose sheep. Of these, bears, wild cats, and cougars are easily killed by hunting and trapping, and timber wolves are rare and fast disappearing in most districts. The coyote, however, remains the great menace to the sheep industry in the range States. It is this animal which primarily necessitates the constant presence of a herder.

It is clear that under the conditions described an experiment on the pasturing, as opposed to the herding, of sheep requires first of all the construction of a coyote-proof inclosure. The construction of such an inclosure was approved by the Forest Service. Specifications for the fence were furnished by the Biological Survey. The Wallowa National Forest of northeastern Oregon was chosen as the region for the experiment. In consultation with Mr. Howard K. O'Brien, the forest supervisor, and Mr. Walter A. Fay, forest ranger, an area of 2,560 acres was selected around the old camp known as "Billy Meadows," where sheep-killing animals were abundant. Mr. James T. Jardine was appointed to take immediate charge of the experiment. He arrived at Billy Meadows on June 11, 1907, and, in cooperation with Supervisor O'Brien, proceeded with the construction of the fence, which had already been begun.

The fence was not completed until late in the season, so that the result of a full year's experience with the pasturing of a ewe and lamb band will not be available until the end of the year 1908. The details of the plan, cost, and construction of the fence, however, as well as the results of one month's pasturing of a band of "dry" sheep are presented in the following report. It is desirable that this infor-

Page 7, line 8, read "yeaning" instead of "weaning."

mation be made available to stockmen at once, not only on account of its bearing on the main question of pasturing sheep instead of herding them, but because of its value to those desiring to keep their ewes in absolute quiet during the lambing period. The advantages of a coyote-free lambing pasture will be evident to any sheep man. As suggested by a Wyoming owner, even a smaller coyote-proof inclosure with many gates, around the outside of which the "drop band" can be moved and within which each ewe is placed just before the weaning of her lamb, would save many losses and much expense for extra labor.

The cost of the fence at Billy Meadows was excessive, since it was constructed under unusual difficulties. It should be borne in mind that the cost of wagon transportation of the fencing materials alone was $1,037.46; that the cost of clearing the timber from the fence strip was $1,150.87; that much of the ground where posts were to be erected was very rocky, and that labor cost $3 per day. The various items of expense have been separated in the report, so that any sheep owner in considering the cost of constructing coyote-proof fencing on his own land, for spring or fall or winter grazing, may eliminate such items of expense as are not involved in his case.

Unless some unforeseen accident occurs, a full report on this experiment may be expected in 1909.

OBJECT OF THE STUDY.

Anyone familiar with grazing conditions in the West during the past ten years must have realized that the time was rapidly approaching when the old form of unrestricted occupancy of grazing areas would be no longer feasible and must be superseded by some sort of systematized method. It was evident that so long as the old practice remained it would be impossible to check the abuses which inevitably grew up under it. Not until the establishment of National Forests was it possible to take any effective steps for the preservation of what forage remained, or for the replacement of that destroyed. The task of management, to insure the proper utilization of existing forage, is now fairly under way; that of replenishing and increasing the carrying capacity of the ranges is merely initiated. The need for much experiment and development still remains.

Early in the season of 1907 the question of forage development on grazing areas took definite form. In cooperation with the Bureau of Plant Industry, the Forest Service began a series of experiments for the collection of information that may aid in determining how the carrying capacity of grazing lands may be increased. This work fell into three divisions:

1. Experiments to gain more thorough knowledge of the propagation of native forage plants.

2. The introduction of cultivated grasses.

3. The collection of information that will make it possible to do away with the unnecessary destruction of forage by herding and trampling.

This last included: (*a*) Careful observation of the management of sheep and cattle on the National Forests, and the effect of such management upon the area grazed, and (*b*) a specific experiment for the purpose of determining the action of sheep when allowed perfect freedom in an area protected from marauding animals, and the result of such a system upon the forage crop. Such a test required a coyote and wolf proof fence.

The scope of this report is to discuss the selection of the experimental area, the construction of the wolf and coyote proof fence, the attitude of animals toward the fence, the actions of the sheep when turned at liberty within the inclosure, and the result of such a grazing system upon the forage crop.

COYOTE-PROOF PASTURE.

LOCATION.

The Wallowa National Forest, with headquarters at Wallowa, Oreg., was chosen by the Forest Service for the experimental work. The grazing of cattle, horses, and sheep is carried on very extensively on this Forest, and every phase of the industry is met with. During the past season 161,565 head of sheep and 18,100 horses and cattle were grazed there under 445 permits.

The area finally selected is on the Chesnimnus division of the Forest, in a locality known as "Billy Meadows," with an elevation of from 4,800 to 5,400 feet. It has been used for grazing for the past twenty years, for the most part by sheep. The range on the north, east, and south is summer grazed by sheep, between July 1 and September 25. On the west is the large cattle district No. 5, on which, in 1907, 2,500 head of cattle were grazed.

The location is on or near the headwaters of Peavine, West Peavine, Cougar, Broady, and Summit creeks, a site very suitable for a test against animals. Grizzly bears, black bears, brown bears, cougars, cats, coyotes, and badgers are common in the neighborhood, and with the exception of the cougar, each class came in contact with the experimental fence.

In 1907 the area was not wholly free from winter snow until about June 1, and occasional light snows fell until June 20. The autumn snowstorms begin any time after September 1, so that the average grazing period is from July 1 until September 20–30, practically three months.

The pasture comprises areas heavily timbered, areas of open forest, principally yellow pine and red fir, and glade areas, for the most part on scab-rock ridges. These divisions will be later considered in discussing grazing capacity.

SURVEYING.

The pasture of 2,560 acres, four sections, is in the form of a square; the lines run north and south, and east and west, respectively. The directions were taken by a compass, and the chaining done parallel to the ground surface in order that the exact amount of fencing necessary could be determined. The cost of surveying was $31.12.

CLEARING FOR FENCE LINE.

As the section is rather heavily timbered, there had to be a clearing outside the fence line wide enough to prevent cats or other animals from springing to the inside from rocks and trees. It was also necessary to have sufficient clearing inside the fence line for travel by saddle horse or pack horse, in making necessary repairs. In order to keep down the cost, this clearing was made as narrow as seemed safely possible, 6 feet inside and 12 feet outside the fence line.

In order to have the fence actually 5 feet in height in all places it was necessary to level all stumps outside the fence line down to the surface of the ground. This made clearing slow and difficult. In very many instances the trees could not be sawed down to the ground surface, owing to the presence of rocks and gravel. In fact, it was almost impossible for men to attempt such work and make any headway at all. Accordingly, the trees were sawed at a height of from 4 inches to 1 foot above the surface of the ground, depending upon conditions. This, of course, left a considerable number of stumps to be removed by other means. No unnecessary waste was occasioned, and, wherever possible, valuable trees were left standing. The total cost of clearing, exclusive of removing stumps, which will be presented later, was $1,150.87.

THE FENCE.

SPECIFICATIONS.

Specifications for a fence to keep out coyotes, wolves, and cats, drawn up by Mr. Vernon Bailey of the Biological Survey, were submitted to the Forest Service May 9, 1907, by Dr. C. Hart Merriam, Chief of the Survey. The substance of these specifications was as follows:

Eight-foot posts should be set 2½ feet in the ground at intervals of 20, 30, or 40 feet. On an uneven surface they should be close together and on a level surface they may be the maximum distance apart.

One "hog wire" with 4-point barbs 2 inches apart should be stretched along the surface of the ground. Slight elevations should be cut through and cavities securely

filled to prevent animals from crawling under this wire, and swinging gates suspended across streams and washes.

A 36-inch strip of woven-wire fence should be stretched with its lower edge 3 inches above the ground wire.

Stretch a light barbed wire 6 inches above the woven wire and a heavy twisted wire without barbs 8 inches above this.

In all cases the wires must be on the outside of the posts. All of the wires, but especially the strip of woven wire, must be stretched very taut. If there is any danger of the tension slackening, the wires should be connected by vertical wires at intervals of 8 or 10 feet.

Material.—For the woven-wire strip several standard makes were mentioned as satisfactory. Triangular meshes were recommended as better than square meshes of even smaller dimensions. The prices of the fences specified ran from 28.35 cents per rod, for a 34-inch fence with 4 and 8 inch triangular meshes, to 31 cents for several 36-inch fences, some with 5-inch and some with 6-inch meshes.

For the bottom or ground wire a closely barbed hog wire was recommended, at a probable initial cost of 3 cents per rod.

For the first wire above the woven-wire strip the Survey advised a light barbed wire, with barbs about 3 inches apart, which would cost, according to the catalogue of one manufacturer, $1.95 per spool of 80 rods, or 2.45 cents per rod.

For the top wire any heavy twisted wire without barbs, at a cost of 2 cents per rod, would meet the requirements.

Mr. Bailey estimated the initial cost of wire as follows:

Woven wire, 36 inches high, per rod	$0.31
Hog wire, per rod	.03
Barbed wire, per rod	.025
Twisted wire without barbs, per rod	.02
Total cost of wire per rod	.385
Total cost of wire per mile	123.20

"The actual cost of the fence," he added, "will depend on the cost of posts, price of labor, and freight on wire."

The conclusion of the specifications was as follows:

Protection from cats.—The Biological Survey has not as yet made the necessary tests to be in a position to recommend a fence for protection of stock from mountain lions and wild cats, but from a general knowledge of the habits of the animals Mr. Bailey thinks it not improbable that the wolf-proof fence may prove effective in keeping them out. If it fails to do so the addition of another wire, preferably barbed, 10 inches above the top wire, would greatly increase the probability of excluding these animals. Where rocks or elevations occur near the fence on either side, the fence should be made correspondingly higher by additional wires to prevent the cats from springing over.

The specifications of the Biological Survey were drawn up with special reference to coyotes and timber wolves. After a consideration of the conditions on the experimental area and elsewhere it was thought that the following modifications of the specifications were essential:

1. That in order to be effective against wild cats, the woven wire must have a triangular mesh of 4 inches throughout, instead of 6 inches, or 4 and 8 inches, as originally specified.

2. That in order to be effective against bear, the top wire should be barbed instead of a cable wire.

3. That the woven wire should be 42 inches instead of 36 inches in height.

4. That the posts should be 16 feet apart instead of from 20 to 40 feet.

Peeled tamarack and red fir posts, not less than 5 inches in diameter at the small end, were used.

CONSTRUCTION—PRELIMINARY.

The difficulties encountered in the construction of such a fence and, consequently, the practicability and cost depend to a very great extent upon local conditions. For this reason it is thought best to discuss, somewhat in detail, each phase of the work, with the hope that it may serve as a basis from which an estimate may be deduced for any locality.

Post making.—The average cost of making posts was found to be 12⅓ cents each. This information, however, might be very misleading without further explanation.

The number of posts that can be cut by two men, well equipped with saw and wedges, varies somewhat with the accessibility of timber. Where the timber is plentiful, about the right size and of good length, two men can cut from 100 to 125 posts in eight hours. Where a moderate amount of time is spent in selecting trees and the timber is of medium grade the number for two men in eight hours is from 80 to 100, according to observation in this instance.

Tamarack posts will not peel in the region after August 1. Red fir at that time of the year is somewhat easier, but still difficult. Through June and early July, however, the bark slips easily, and two experienced men, supplied with the necessary peeling "spuds," can peel nearly as many as two men will cut in the same time—from 75 to 100 in eight hours. Later in the season the number often was as low as 65.

In some instances, where the use of round, peeled tamarack or Douglas fir posts would have necessitated a half-mile haul, split tamarack and Douglas fir posts were used. Where suitable trees can be found for splitting, these posts, of the required dimensions, can be made for from 4 to 8 cents each, depending upon the size of the trees and the ease of splitting.

It was found that thoroughly dry, solid, split posts were really better than round, sappy ones, owing to the fact that the latter, within one or two months, season crack in the staple line, which permits many staples to drop out and release the wires.

Distribution of posts.—The cost of distribution depended upon the distance hauled and the ground hauled over. All distribution at

Billy Meadows was done by dragging. Where stumps were thick the distribution of the large, green, and "soggy" posts was slow. At times it was necessary to go a considerable distance into the woods to secure the desired timber; at other times posts were hauled a great distance along the clearing, in order to utilize serviceable timber that had to be cut down. With an average of 200 yards, one man with one good horse would distribute from 100 to 150 posts in eight hours. The average cost was 3 cents for each post.

Transportation of wire.—The transportation of wire was extremely difficult. From Chesnimnus Creek to Billy Meadows, 16 miles, the road was an old one used for hauling poles and for light traffic. Although it was improved as much as possible, it could not be made suitable for heavy freight teams. As a result the freighters took five days to travel the 40 miles from Enterprise, Oreg., to Billy Meadows. The total distance freighted, from Elgin, Oreg., to Billy Meadows, 86 miles, required thirteen days for one round trip. The outfits, with three wagons and eight horses, hauled from 7,500 pounds to 8,500 pounds by "dropping trail" on all hills. The freight, at 2 cents per pound, amounted in all to $1,037.46.

Wire distribution.—The distribution of wire over the 8 miles of fence line was a tedious and difficult task. It was simply a case of getting to the fence line wherever possible, and from such places distributing the wire by pack horse or in any way practicable. In one instance a 500-pound roll of mesh wire was rolled 120 rods with a saddle horse in order to cross the main canyon of the Peavine. The cost of distributing the mesh wire was 3 cents a rod, the barbed wire one-third cent a rod.

THE WORK OF BUILDING.

The actual work of building the fence consisted of digging holes, setting posts, stretching wire, and "finishing."

Digging holes.—The cost of digging holes 2½ feet deep and large enough for posts from 6 inches to 16 inches in diameter varied with the character of the ground. Every condition was met with, from an ashy soil of an old fire bed to a solid volcanic rock, and more difficult still, a seamed rock formation that caved into the drill hole, making powder work almost impossible. The intermediate varieties were scab rock, lone "niggerheads" and bowlders, gravel, soft stone, hard pan, blue "gumbo," and stiff white clay, in many cases containing numerous tree roots.

The best record was 124 holes in four hours, by four men. The soil in this case was easy to dig, though it was in one of the most thickly timbered sections of the fence line, and many roots were encountered.

The minimum actual working number in the solid rock formation was 4 holes in eight hours, by two men. Powder was not used in

any case where it was possible to dig a hole. In consequence, many were dug in almost solid rock, and took from one-half hour to an hour of time. Where there were no rocks or just a few float rocks, one man could dig, on an average, from 30 to 40 holes in eight hours, even though the soil contained gumbo or "hard pan" with occasional roots. In a few instances holes of any sort were altogether impracticable.

The total cost of digging 1,875 holes and distributing and setting the same number of posts, with labor at $3 per day of eight hours, was $671.50.

"Jacks."—Seventy holes were dug in a formation that could be worked with pick, bar, and shovel to a depth of not more than from 4 inches to 1 foot before a solid volcanic bed rock was reached. The remaining 1½ feet had to be drilled and removed with giant powder, one stick, No. 2, to each hole. This work proceeded at the rate of from 4 to 7 holes a day for three men, two drilling and one cleaning out the holes after the shot. The cost was $1.25 or more for each hole made.

A careful investigation, by testing the soil of the fence line with drill and hammer, showed that giant powder would be needed in the construction of about 800 holes. This was impracticable from the financial side, and it would have been impossible, with the force available, to have completed the fence within the time limit. Consequently, some form of support had to be devised that would act as a substitute for the hole. In the search for such a contrivance four points at least had to be considered.

1. It must not lessen the effectiveness of the fence against animals.
2. It must produce stability.
3. It must be constructed of material at hand.
4. It must be as economical as possible.

Many forms were considered, but the one which seemed best was as follows:

Two supports about 4 inches in diameter were spiked to the post 4 feet from the ground and at an inside angle of approximately 45° with the post. One of the supports was placed in a direction approximating the fence line but not closer than 6 inches to the wire at the bottom. The other was placed at right angles to the first, and thus at right angles to the fence line. These supports act as braces, and prevent the post from falling, or being pushed inward or along the fence line in one direction. To these two supports and the post a triangular platform was spiked, about 4 inches from the ground surface. The pyramid-shaped space thus formed was filled with rock to a weight of from 250 pounds to 1,000 pounds, according partly to the size of the "jack," but especially to the size and kind of rock available, since much more weight was possible where large, hard rock could be obtained. This weight acts down-

ward with a weight arm of about 18 inches, and at an angle of approximately 45° with the fence line, and thus prevents overturning outwardly or along the fence line in the direction not provided for by the support. To add to its efficiency, the post was set in the ground from 6 inches to 12 inches, wherever possible, which secured the bottom against slipping.

The making of such supports, or "jacks," required from twenty-five to thirty-five minutes on an average. The time depended somewhat upon the workman's ability to handle an ax and his judgment in cutting timbers. A man of ordinary speed and accustomed to the work can make an average of 20 "jacks" in an eight-hour day if the timber is distributed as poles at each post. The highest number made in one day was 26. Where "jack" timber

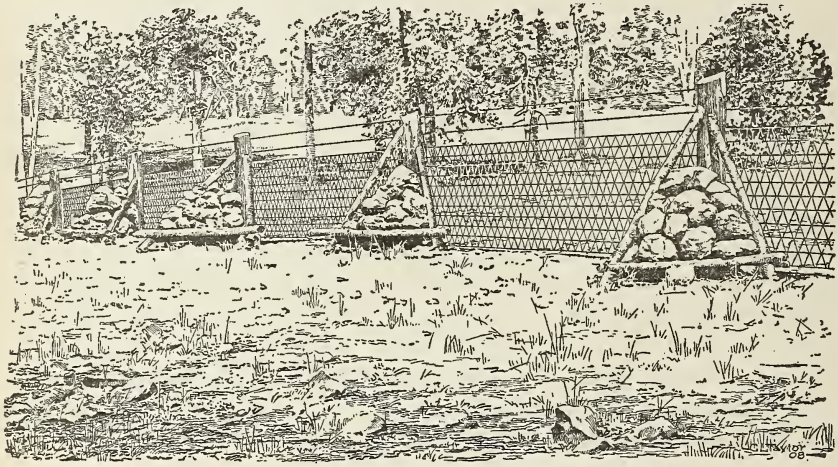

FIG. 1.—Section of fence line, showing "jacks" on scab land.

is moderately accessible one man can cut and distribute material for two or sometimes three builders.

With labor at $3 for eight hours' work, the average cost of building 675 "jacks," including the labor of cutting and distributing the necessary timber except the post was $0.292 each.

It was necessary, in almost all cases, to haul the rock for the "jacks." The distance varied from 30 feet to three-eighths of a mile. With the exception of perhaps 90 "jacks," where a wagon was used, the stone was hauled on a sled stone boat, drawn by one or two horses. Most of the work was done by one man with a sled boat, 5 by 3½ feet, drawn by one horse. From 300 to 1,000 pounds could be drawn at one load, thus filling a "jack" at a load.

With such equipment, one man in eight hours would ballast from 15 to 30 "jacks;" the number depends entirely upon the available rock. Where the haul varied from 25 yards to 150 yards, and medium-

sized or large rock could be obtained, 30 "jacks" could be filled by one man in eight hours. The number reached as high as 35 in one day, and no lower than 15. With labor at $3 for eight hours' work, horse hire $0.75 per day for one horse, the average cost of loading the "jacks" was $0.15 each.

The total average cost of cutting and distributing material, making a "jack" and filling it, with labor at $3 and horse hire at $0.75 per day, was $0.446. The average cost of digging a hole and setting a post, excluding the holes where giant powder was used, was $0.32. While the "jack" cost $0.126 more than a post set in a hole, it is in the long run, where a fence is to stand any great length of time, just as cheap, because tamarack and Douglas fir posts set in the ground will rot in from two to five years, while the "jack," if it rots at all, will not do so for many years. For stability it equals and in many cases excels a post set in the ground, for it is almost impossible to make a post solid where water is in the hole or where the soil is very soft or of ashy material.

Setting posts.—The task of setting posts was not difficult when it was properly handled. Four men put in 590 posts in four days, and in one instance five men set 250 posts in one day of eight hours. The average rate when the work was directed on the ground was about 40 posts to the man in eight hours. A crew should consist of five or six men. Less than three materially reduces working capacity, if any great number of posts are to be set. The chief difficulty was in getting men to "tamp" the earth properly, so that the posts would stand firm. Solid "tamping" was required for every 4 inches of earth from the bottom of the hole to within 1 foot of the ground surface.

Wire stretching.—To aid the reader the wire specifications are here restated:

1. On the surface of the ground a four-point barbed hog wire.
2. Three inches above this a 42-inch woven-wire fence with 4-inch triangular meshes.
3. Six inches above the woven wire a common barbed wire.
4. Eight inches higher a second common barbed wire.

To construct such a fence, coyote-proof, over canyons, gullies, hills, stumps, and rocks is by no means an impossibility, but it requires time and ingenuity.

The system of bracing found to be most satisfactory under the conditions existing at the pasture is shown in figure 2.

The woven wire came in 10-rod and 30-rod spools, which weighed 160 and 480 pounds, respectively. The large ones were rather awkward to handle, but on the whole they were more satisfactory than the 10-rod rolls as they eliminated much splicing of wire—a laborious task.

The unrolling was done as conditions demanded, by hand, with a saddle horse, or with a horse and a wheelless cart devised for the purpose. The wire could be rolled on the ground over small stumps and rocks without injury to the mesh.

Much difficulty was encountered in getting the wire to conform to the irregularities of the surface. At every decided change of angle the wire had to be cut for the entire width, and the bottom or top, as the case might be, drawn back until the whole took the angle of the ground surface. The greatest difficulty was encountered in sharp V-shaped draws or canyons. In such cases it was almost impossible to place the wire properly to the very bottom of the draw, because the type of stretcher that was used requires at

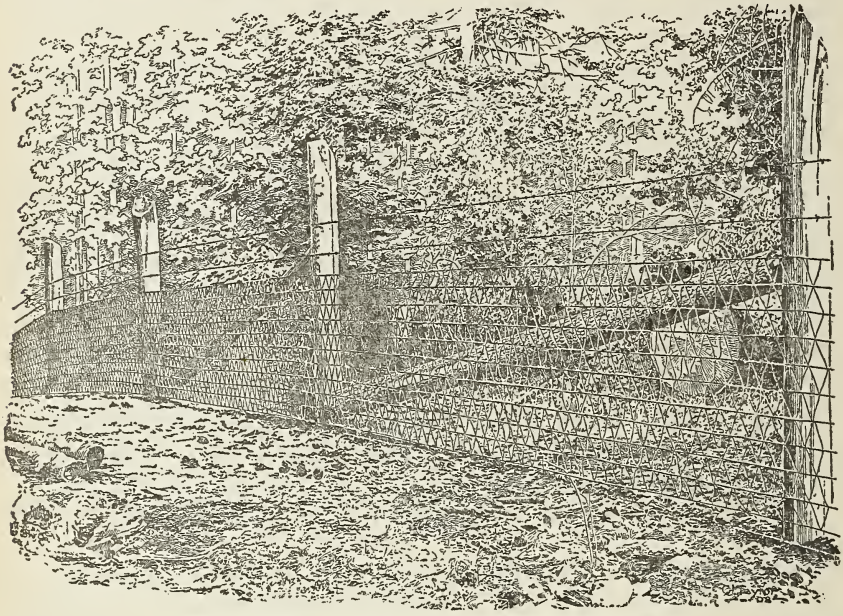

FIG. 2.—Section of fence line, showing system of bracing.

least 8 feet of space between the support pulled from and the post to which the wire is stapled, with both points on the same slope and at the same angle. In V-shaped canyons it was impossible to meet such conditions, and it was necessary to approach the desired placement as nearly as possible and then weave barbed wire in the bottom of the draw.

It was found possible to make the woven wire conform to small irregularities of surface without cutting, where there was no decided change in the general angle. This was best done by making long pulls of from 10 to 20 rods. The wire was first slightly tightened and then tacked to position on every post, the staples being placed so as to allow more tightening. The final stretch was then made and the wire would take its place without "buckling."

The best crew for manipulating the stretcher consists of three men. Two staple and arrange for a pull, while one puts in braces; then all three manipulate the stretcher. The amount of wire placed in eight hours depended upon the irregularities of surface. It varied from 4 rods to 108 rods for three men in eight hours, the low record being made in a V-shaped canyon, the high on a comparatively even slope. A good stretcher will tighten almost any amount at one pull, but it is almost impossible to set a post that will withstand the pull of more than 20 rods. The average pull on the 8 miles was about 6 rods.

The placement of the two top barbed wires was comparatively easy and inexpensive. After the wire was unreeled, three men, one stretching and two stapling, could put up as much as 1¼ miles of both wires in eight hours. It required two men to do the necessary pack-horse distributing and unreeling for the same amount in eight hours.

The bottom wire was not so easily placed, owing to the many irregularities to be trenched through. However, this work went at the rate of from one-fourth to one-half mile a day for three men working.

A much greater task was encountered in making the bottom coyote proof and wolf proof. These animals do not dig to any great extent, but where the dirt is very soft or newly filled in it is merely a matter of a little scratching for them to get under the fence. Accordingly, filling in with loose dirt was not at all effective. Wherever blasting had been done, holes varying from 2 feet to 4 feet in depth and from 4 feet to 15 feet in length were left under the fence. Such places were mended by bedding logs long enough to fit as "mud sills" into a trench dug in the solid ground at each end of the hole. If one log was not sufficient, smaller logs were placed underneath it. The dirt was filled in, and in time it will be solid ground.

Wherever the ground was exceptionally soft or of decaying material believed to be insufficient for turning coyotes, a fourth barbed wire was placed in a trench and covered. This was done in much of the timbered area.

There were perhaps twenty or more canyons and gullies where it was impossible to fit the woven wire down because this would materially weaken the fence at the top. All such spaces were filled in by stretching barbed wires, no more than 3 inches apart. These wires were secured to a post at each end and stayed by being stapled to stakes driven into the ground inside the fence, close enough to insure stability and prevent the wires from spreading apart. Always one wire was placed below the surface of the ground.

In a few places the fence line ran along hillsides in such a way that the ground outside the pasture was higher than that inside, which rendered the fence, to all intents, lower than the desired height. In such places an extra barbed wire was placed 8 inches above the top wire of the original fence. This work of patching was very slow and

tedious and involved considerable expense that would not be encountered in an open, comparatively level country. The whole expense for this work was $171.

Removing stumps.—Most of the work of removing stumps, rocks, and mounds was done after the fence was completed. Few, if any, stumps were removed which could have been left without detriment to the fence, and yet the work was hard, tedious, and expensive. After the fence line was definitely located in the clearing the larger stumps in the line and the objectionable ones outside were worked with giant powder. In solid ground stumps from 1 to 4 feet in thickness were often blown entirely out, but many times, where the ground was soft, a great amount of dirt would be removed, and yet the stump in part or whole would remain and have to be worked out with an ax. The amount of powder used varied with the kind of stump, its size, and position. Stumps a foot or two in diameter were removed with from 2 to 12 sticks of No. 2, ¾-inch giant powder. Fir and pine stumps from 2½ to 4 feet in diameter required from 25 to 45 sticks. For this work 638 pounds of giant powder, with caps and fuse, were used; total cost, $137.

The most tedious part of removing stumps, rocks, and mounds, however, came in the finishing work with the ax. It was work that the men did not want to do, and consequently it moved slowly. The total cost, with labor at $3, was $250.50.

It may be thought that extra barbed wires might have been used instead of incurring so much expense for removing stumps, but the efficiency of the fence lay in the woven wire and in properly securing the bottom. Barbed wire can replace a woven fence only by becoming a woven barbed fence. Stumps or rocks from 6 to 15 inches in height would have the practical effect of lowering the fence by that much—that is, of using a 36-inch or 30-inch woven fence. As this was an experiment expected to serve as a criterion of efficiency, the stumps were removed.

Gates.—The pasture is provided with two gates, one at the south side, where the main wagon road passes through, and one a half mile south of the northeast corner, on the trail to camps and settlements beyond.

A summary of the expenditures which have just been noted in detail is given in Table 1.

TABLE 1.—*Summary of expenditures.*

Equipment (special, 2 stretchers)		$9.00
Materials:		
2,640 rods lawn fence, at $0.664 per rod	$1,752.96	
5,231 pounds barbed wire, at $3.80 per hundredweight	198.77	
4,001 pounds hog wire, at $3.80 per hundredweight	154.00	
Spikes, nails, and staples	55.45	
		2,161.18

TABLE 1.—*Summary of expenditures*—Continued.

Supplies:		
Special (explosives)	$137.00	
Miscellaneous	6.60	
		$143.60
Transportation:		
Materials	1,022.46	
Supplies	15.00	
		1,037.46
Construction:		
Road construction	74.63	
Surveying area	31.12	
Clearing for fence line	1,150.87	
Making posts (2,600)	316.75	
Digging holes and setting posts	671.50	
Making "jacks"	301.05	
Stretching wire	390.70	
"Patching"	171.00	
Removing stumps	250.50	
Miscellaneous labor	49.25	
		3,407.37
Telephone and travel		5.70
Total		6,764.31

OBSERVATION ON THE ACTION OF ANIMALS.

CLEARING THE PASTURE.

In early June, when the survey of Billy Meadows pasture was made, the proposed area was overrun with animals of various kinds. Bears were working on scab area; deer were trailing about; an occasional cat track was seen, and, although it was rather early in the season for coyotes, there were a few in the neighborhood.

At first it was thought that to clear the pasture of animals it would be necessary, after the fence was completed, to drive them all to a suitable corner and kill those that are destructive to sheep. However, before the fence was completed, the inmost depth of the area was penetrated by men going to and from work. The constant noise of falling timbers, the ring of ax and hammer, blasting, shouting, horse bells, and various other disturbances occasioned by a large construction camp gradually diminished the charm of the pasture area as a permanent home for wild animals. The large game decreased in number, though coyotes very materially increased with the increase of sheep which were summer grazing near by.

Accordingly, August 25 found the inclosure comparatively free from animals destructive to sheep, with the exception of coyotes. It was thought best to allow Mr. J. K. Carper, who had been selected as hunter, to begin clearing the inclosure of animals before the final work of patching and of removing stumps was completed.

Dogs.—The hounds used were as follows: Two pure-bred foxhounds, one staghound, one bloodhound and bulldog, and two bloodhound-bulldog-foxhound pups.

The foxhounds were very keen on scent, and, for the most part, the other dogs relied on them, unless the trail was very hot. With

the exception of the staghound, none of them were fast, but this was of little disadvantage where there was so much fallen timber.

For five days, beginning August 29, Mr. Carper hunted every portion of the inclosure with his hounds. With the exception of one porcupine, nothing was found but coyotes. For the first three days the animals which were trailed found openings not yet closed in the fence line and passed out. On September 1, however, the hounds gave hot chase to a coyote, finally driving him to a series of "jacks" on the fence line. From the action of the dogs and from the fact that the track was not found on the following day, it was concluded that the animal had passed out over a "jack," which was very probable. On September 2 the area was reported ready for the experiment. From this time until October Mr. Carper was engaged in watching the fence line, reporting on the action of animals and his own procedure in dealing with them.

LOSS OF SHEEP.

The management of the sheep, and consequently their action, depended largely upon the success in dealing with animals destructive to sheep. Therefore, the observations made on the action of animals, with the necessary discussion, are presented first.

From July 25 until the pasture was completed, on September 3, the experimental band was under the care of J. C. Smith, a herder who later became the sheep tender. During this period the Government representatives had no part in the management of the band. It was simply herded by the methods customary in the vicinity, and was subject to all losses that might occur to any other band near by.

Table 2 gives the number of sheep killed, and those unaccounted for during the period:

TABLE 2.—*Loss of sheep July 26 to September 3, before the band was turned loose in the pasture.*

Date.	Animals which attacked.	Where attacked.	Sheep killed and found.
July 31 to August 15	Coyotes	On bed ground and range	0
August 15	do	On range	1
August 18	do	do	3
August 19	do	do	5
August 25 to 30	Bear	do	12
Total			21

SUMMARY.

Number of sheep in band July 25		2,495
Killed for mutton between July 25 and September 3	5	
Killed by animals between July 25 and September 3	21	
Unaccounted for between July 25 and September 3	6	
		32
Number turned loose in pasture September 3		2,463

A small bunch of about 75 head was lost by the herder between August 12 and 15, and found later by a neighboring herder. It is probable that many of the sheep killed were from this bunch.

The loss of sheep during the experimental period, while the sheep were loose in the pasture, is shown in Table 3:

TABLE 3.—*Loss of sheep during the pasturage period, September 4 to October 4.*

Number of sheep in band September 3		2,463
Killed by bear September 30	1	
Killed by coyote October 1	1	
Killed by poisonous plants	1	
Drowned	1	
Snagged	1	
Killed for mutton	2	
Unaccounted for	4	
		11
Number taken out of the pasture October 4		2,452

OBJECTS OF OBSERVATIONS.

The daily observations on the action of animals with regard to the coyote-proof fence during the month of the test were made with a view to answering the following points: (1) The number and kind of animals observed, (2) when and where each appeared, (3) the attitude of each toward the coyote-proof fence; and, secondarily, (4) the action of the hounds in dealing with them.

On the second day of the experiment, September 5, it was found that one coyote had succeeded in evading the hunter and his hounds in their effort to clear the inclosure and was still at large within the pasture. While this animal was the source of much annoyance in the work of supervising the experiment, its presence afforded an opportunity for a more thorough test against coyotes, as it enabled the hunter and hounds to press the animal closely and increase his desire to get through the fence.

Following is the data collected in answer to points 1, 2, 3, and 4:

1. Number and kind of animals: (*a*) Some animal was at the fence line every day except one, after the sheep were turned loose on September 3. (*b*) Those observed were coyotes, grizzly bears, black bears, cats, and a badger. (*c*) Coyotes were known to be present every day but one.

2. Time of appearance: All animals appeared chiefly during the night or early morning, and at every point in the fence line, inside and out.

3. Attitude toward fence: (*a*) Coyotes evinced a desire to get through the fence line, by following it for 6 or 8 miles in one night. One, at least, inside was under pressure to get out, because for days in succession he was run from 1 to 10 miles by hounds. No coyote passed through or over the fence in either direction. (*b*) On three occasions listed, grizzly bears appeared at the fence line. On those three visits they went through the fence four times. Once only, as far as known, did a grizzly bear turn back after trying the fence. (*c*) Bears, other than grizzly, appeared at the fence line at least five times, and made at least four attempts to get in, but failed each time. (*d*) One cat came to the fence line, but apparently did not attempt to get through. One large bobcat was killed by the hunter outside the fence line. (*e*) One badger came to the fence line and passed to the inside by digging under.

4. Action of hounds: (*a*) The hounds chased, caught, and killed one coyote outside the pasture. (*b*) They failed to catch one on the inside. (*c*) They treed the bobcat which was killed. (*d*) They trailed, caught, and helped to kill one grizzly bear.

The coyote within the inclosure succeeded in baffling the hounds and the hunter until the last. It was necessary to chase him enough to frighten him from any attack on the unprotected sheep, though other things could not be neglected. After the first few days he could not be found in the afternoon, but every night he would come to the fence line and follow it closely—sometimes the entire distance of 8 miles, and seldom for less distance than 2 miles.

The animal succeeded in escaping the hounds by getting into the area of thick fallen timber along the Peavine. Morning after morning the foxhounds would pick up the track and follow it for hours, losing it nearly always in the same area. When the thick down timber was reached, where logs lay practically horizontal at heights of from 4 to 15 feet above the ground, the dogs would trail from one log to another, backward and forward and in circles, until they were bewildered. Sometimes they would succeed in getting the coyote out, but more often not. Not infrequently they would come from this area and immediately take up the cold outgoing track, showing that their losing the animal in the timber was due to shrewdness on the part of the coyote and not to the coldness of the track. At no place in the pasture was it necessary for the coyote to run in the open for more than one-fourth mile, so that there was only a chance possibility of the hunter getting a shot, and then only when the animal was running at full speed.

From the facts just given, and from close personal observation, it can be said that the fence was effective in turning coyotes during the month of test. Whether it will be as effective after they become thoroughly accustomed to it remains to be proved. The outlook, however, is very favorable.

GRIZZLY BEARS.

The first grizzly bear that entered, September 4, got through the 6-inch space between the woven wire and the first barbed wire. Apparently he pushed the woven wire inward and the barbed wire upward with his powerful "arm" until the space was large enough for his head and shoulders. Then he forced his tough, woolly body through. The wires were relaxed so that the 6-inch space was spread to 18 inches after he worked his way through. In going out he made his attack in the same way, except that he was shrewd enough to choose a space where the timber brace extended from post to post, giving him a step upward.

The large grizzly bear that came in September 30, and afterwards, made his first entrance as just described, but each time afterwards he passed through the 8-inch space between the two top barbed wires.

OTHER BEARS.

Black and brown bears made at least five attempts to get through, but in every instance they failed. In one case a large fellow made a space of 20 inches between the mesh wire and the barbed wire above, and yet turned back.

Whether the fence will prove of sufficient strength to keep them out when they become accustomed to it is doubtful. They lack persistence, but they might spend more time in their efforts after their suspicion had worn away.

CATS.

With cats the observations were so few as to justify almost no conclusions. However, it is probable that cats, especially if they were crowded, would easily climb over the fence or through it. Not infrequently shepherd dogs and hounds would jump at the top wire, hang by their feet for a moment, and then pass over. Many times, too, they would spring to the top of the mesh wire, which in no way inflicted wounds, and then force their way through the 6-inch space between the woven wire and the first barbed wire. They always met the barbs squarely and were very seldom even scratched.

BADGERS.

Badgers, of course, will dig under, and the only thing possible where they exist would be to watch for their places of entrance and repair them to prevent coyotes from getting in.

SUCCESS OF FENCE.

To sum up, it is safe to say that during the test of the season of 1907 the fence proved successful as a protection against coyotes, not successful as a protection against grizzly bears, doubtfully successful against black and brown bears, still problematic against cats, and not successful against badgers.

CHANGES IN FENCE SPECIFICATIONS.

The following changes are suggested in fence specifications to meet conditions similar to those at Billy Meadows pasture:

DEFECTS.

1. Posts 16 feet apart do not sufficiently support the barbed wires to prevent them from being stretched upward or downward.
2. A 6-inch space between the woven wire and the first barbed wire above is too large.
3. An 8-inch space between the two top barbed wires is too large.
4. The present specifications require too much patchwork to secure the bottom of the fence.

ALTERATIONS.

1. A 3-inch stay, 5½ feet long, placed midway in each panel, driven 6 inches into the ground and the wires stapled to it.
2. A barbed wire 4 inches above the woven wire.
3. A second barbed wire 6 inches above the first.
4. A third barbed wire 6 inches above the second.
5. The whole fence lowered 1 inch with respect to the ground surface.

The specifications then would be as follows: Posts set 2½ feet in the ground and 16 feet apart; a 3-inch stay 6 inches in the ground and midway between every two posts; 1 inch below the surface of the ground a four-point barbed hog wire; 3 inches above that a 42-inch woven lawn fence with a 4-inch triangular mesh; 4 inches above that a common barbed wire; 6 inches above that a second barbed wire; 6 inches higher a third barbed wire.

ACTION OF THE SHEEP AT LIBERTY IN THE INCLOSURE.

In the latter part of May and early June Mr. Frederick V. Coville and Supervisor O'Brien conferred with the leading sheep owners of Wallowa County regarding the experiment, its feasibility, and the possibility of arranging for a volunteer band of 2,500 head, to be placed at the service of the Government representatives for carrying out the proposed experiment.

Much credit is due to the sheep owners for their progressive spirit. They arranged to provide the number and class of sheep asked for. They also readily accepted regulations proposed for the management of the sheep during the period of experimental work. The band turned at large in the Billy Meadows pasture numbered, as was told earlier, 2,463 head. A copy of the agreement follows:

COYOTE-PROOF PASTURE AGREEMENT.

We, the undersigned sheep owners and representatives of the Forest Service, in consideration of the mutual benefits to be derived from the experiment herein described, subscribe to the following articles of agreement:

ARTICLE I. The primary object of this experiment is to ascertain whether within an area protected from wild animals a band of sheep can be pastured without herding and without bedding down together in large bunches in any one place, and whether under such a system the condition of the vegetation will be improved and the carrying capacity of the range increased.

ART. II. The Forest Service agrees to inclose a pasture of approximately 2 miles square by a fence constructed as follows: Posts set 2½ feet in the ground and 16 feet apart; on the ground a hog wire; 3 inches above that a 42-inch woven wire with a 4-inch triangular mesh; 6 inches above that a barbed wire; 8 inches above that a second barbed wire; the upper part of each post protected on the outside with two loops of hog wire.

ART. III. The Forest Service agrees to furnish a hunter to clear the pasture of wild animals and patrol it during the period of grazing.

ART. IV. The Forest Service agrees to furnish a man to superintend the experiment in person throughout the grazing period.

ART. V. The sheep owners agree to furnish until October 31, or such earlier date as may be satisfactory to the Forest Service, for the purpose of the experiment, the number and class of sheep set opposite their respective names.

ART. VI. The sheep owners agree to furnish a sheep tender who shall be satisfactory to the Forest Service.

ART. VII. The sheep owners agree that the sheep shall not be herded within the pasture except by the direction or with the consent of the officer superintending the experiment.

ART. VIII. The Forest Service shall not be responsible for any injury to or any losses among the sheep pastured in this inclosure.

QUESTIONS DISCUSSED.

As stated in Article I of the agreement, one object of the experiment was to learn, in detail, the action of sheep when they are allowed perfect freedom in an inclosure and protected from annoyance by animals, and to note the effect of such grazing upon the carrying capacity of the range.

With regard to the first of these topics, the action of the sheep, information was gathered on the following points:

1. Do sheep separate into small bands when allowed to graze at random, unmolested by animals?

2. To what extent do sheep scatter and graze openly, if allowed perfect freedom?

3. To what extent do sheep destroy range by rambling about and trailing, if allowed perfect freedom?

4. Do sheep bed together in large bands when allowed freedom?

5. Under these conditions, to what extent do sheep seek the same bed ground night after night?

Table 4 was compiled from the record of daily observations on the action of the sheep during the period of freedom. Information on points 1, 2, 3, 4, and 5 will be found in columns 3, 4; 5; 6; 3, 4; and 7, respectively.

The presence, from first to last, of one coyote inside the inclosure, and the possibility of a grizzly bear coming in any night, interfered somewhat with the free working of the experiment. Every effort, however, was made to allow as much freedom as possible and yet not encourage too great a risk. There were instances when the sheep were rather encouraged to bed in one or another comparatively safe bed ground, but, for the most part, they were unmolested from the time they bedded down at night until the following evening, when it was necessary to find again suitable place for the night. And even then, wherever possible, they were allowed perfect freedom until they had chosen a bed ground; then, if safety required it, they were removed to a more suitable place. In many cases the whole band remained for days with no interference whatever.

1. *Will sheep separate into small bunches?*—On this point Table 4 shows that—

(*a*) The number of bunches varied from 1 to 5 and the approximate number of sheep in each bunch varied from 75 to 2,463.

TABLE 4.—*Action of sheep in coyote-proof pasture.*

[Pasture: 1,300 acres heavy timber, 400 acres open timber, and 860 acres glade area. Sheep: 750 old ewes and 1,713 yearlings.]

1	2	3	4	5	6	7	8
Date.	Time of day.	Number of bands.	Approximate number of sheep in each band.	How grazing.	Approximate distance grazed.	Where bedding.	Remarks.
					Miles.		
Sept. 3	6.15 a. m.	1	2,463	Leaving bed	0	Old bed ground	Sheep counted from corral and turned loose, 2 463 head.
	11 a. m.	1	2,463	"Shaded up"	1½		
	1 p. m.	1	2,463	Scattered	1¾		
	3 p. m.	2	500, 2,000	do	3		
	4.15 p. m.	1	2,463	Open grazing	3½		
	6 p. m.	1	2,463	Bedded at camp	3⅜	On bed ground at camp on Peavine	
Sept. 4	7.30 a. m.	1	2,463	Leaving bed	0		
	10 a. m.	2	150, 2,300	Open grazing	¼		
	11 a. m.	2	150, 2,300	"Shaded up"	⅜		
	2 p. m.	4	150, 1,200, 100, 1,000	Open grazing	⅜, ½, 1, 1		
	6.15 p. m.	4	150, 1,200, 100, 1,000	Bedded	⅜, ½, 1, 1	Two bands on old bed ground, two small bands in field.	
Sept. 5	7 a. m.	4	150, 1,200, 100, 1,000	Leaving bed	0		
	9 a. m.	4	150, 1,200, 100, 1,000	Open grazing	½, ½, ⅝, 1		
	12 m.	4	200, 1,150, 100, 1,000	do	½, ½, ¼, 1¼		
	6 p. m.	3	200, 1,150, 1,100	Bedded	¾, 1¼, 1¾	Two on old bed grounds	One in field; later they were driven together.
Sept. 6	7 a. m.	1	2,463	Leaving bed	0	Bed ground	
	9 a. m.	4	700, 700, 700, 300	Open grazing	¼, ⅜, ⅜, ½		
	2 p. m.	3	1,400, 700, 300	do	½, ½, ¼		
	6 p. m.	3	1,400, 700, 300	In heavy timber (bedded)	⅝, 1⅛, 1½	Two bands on old beds	One in field.
	7 p. m.	2		Bedded		On old bed ground	One small band driven in; others not molested.
Sept. 7	7 a. m.	2	1,500, 1,000	Leaving bed	0	Old beds	
	10 a. m.	2	1,500, 1,000	Open grazing	¼, ½		
	2.30 p. m.	4	800, 100, 150, 1,400	Timber grazing	½, ⅜, 1, 1¼		
	7 p. m.	1	2,463	Bedded		On bed ground at camp	Bands grazed together about 6.30 and went to camp.
Sept. 8	7a. m.	1	2,463	Leaving bed	0	On bed ground	
	11 a. m.	1	2,463	Timber grazing	½		
	2.30 p. m.	4		Open grazing			
	5.30 p. m.	5		do	¾, 1, 1, 1½		All close to camp but in different directions.
	7 p. m.	1	2,463	Bedded	¾, 1, 1, 1½	On bed ground	
Sept. 9	7.30 a. m.	1	2,463	Leaving bed	0	do	
	9 a. m.	5	800, 800, 500, 200, 150	Open timber grazing	½		
	10 a. m.	4	800, 800, 500, 250	"Shaded up"	¾		
	6 p. m.	4		Bedded		Two on old bed ground, two in field	
	6.30 p. m.	2		do		Both on old bed grounds. Two field bands started in.	
Sept. 10	6.30 a. m.	2		do		Both on old bed grounds	
	7.30 a. m.	2	1,000, 1,450	Open grazing in timber	½		
	3 p. m.	4	250, 400, 500, 1,300	Open grazing	1½, 2, 2½, 2¾		

	7.30 p. m.	2	650, 1,800	Bedded	1⅛, 2¼, 2⅝, 3	On old bed grounds	
Sept. 11	6.30 a. m.	2	650, 1,800	Leaving bed	0	do	
	10.30 a. m.	3	650, 400, 1,400	Open grazing (glade)	½, ¼, ¼		
	1.30 p. m.	2	650, 1,800	Open grazing	¾, ½		
	3.30 p. m.	1	2,463	do	1¾		
	7 p. m	1	2,463	Bedded	½, ¼	On camp bed ground	
Sept. 12	7.15 a. m.	1	2,463	Leaving bed	0	On old bed	
	9 a. m.	2	1,000, 1,450	Open grazing (timber)	⅜, ⅜		
	10.30 a. m.	1	2,463	do	⅞, ⅞		
	12 m	2	600, 1,850	do	1¼, 1¼		
	6 p. m	2	600, 1,850	Open grazing	1⅜, 1⅜		
	7.30 p. m.	1	2,463	Bedded	1¼, 1¾	On new bed ground	One small band driven in for protection.
Sept. 13	7.45 a. m.	1	2,463	Leaving bed	0	do	
	10 a. m.	1	2,463	"Shaded up"	½		
	1.30 p. m.	4	500, 300, 1,000, 650	Scattered timber	¾, 1⅜, 1, 1⅛		
	5 p. m	3	500, 300, 1,000, 650	Open grazing	1, 1½, 1½		
	7 p. m	1	2,463	Bedded	1¼, 1¼, 1½, 1½	On new bed ground	No old bed in this section of field.
Sept. 14	6.30 a. m.	1	2,463	Leaving bed	0	do	
	1.30 p. m.	2	600, 1,850	Scattered (timber grazing)	½, ½		
	7 p. m.	2	600, 1,850	Bedded	¾, ¾	One on bed ground, one in field	
Sept. 15	7.15 a. m.	2	600, 1,850	Leaving bed	0, 0	do	
	9 a. m.	1	2,463	Scattered grazing	½, ½		
	2.30 p. m.	2	150, 2,300	Very open grazing	1⅝	On two bed grounds	
Sept. 16	7.15 a. m.	2	150, 2,300	Leaving bed	0	do	
	9 a. m.	2	150, 2,300	Open grazing	⅛, ⅜		
	10.15 a. m.	2	150, 2,300	do	⅜, 1⅛	Trailing, with last herd	
	2.30 p. m.	3	150, 1,200, 1,100	do	½, 2½, 3		
	5.30 p. m.	3	150, 1,200, 1,100	do	⅝, 2⅛, 3⅛		
	6 p. m.	2	150, 2,300	Bedded	¾, 2¼, 3¼	Two on old bed grounds	One band grazed in by tender.
Sept. 17	7 a. m.	2	150, 2,300	Leaving bed	0, 0		
	9.30 a. m.	2	150, 2,300	Scattered grazing	¼, ¼		
	11.30 a. m.	3	150, 1,000, 1,300	Traveling	⅜, 1⅜, 1¾		Trailing.
	2.30 p. m.	4	75, 75, 1,800, 400	Grazing timber	½, 2½, 3		
	6 p. m.	3	75, 75, 2,300	Bedded	¾, 2¼, 3¼		
Sept. 18	6 a. m.	3	75, 75, 2,300	Leaving bed	0		
	9.30 a. m.	2	75, 2,375	Scattered grazing	¼, ¼, ¼		
	11.30 a. m.	4	75, 1,000, 600, 800	Trailing	⅜, 1¼, 1½, 1½		
	3.30 p. m.	4	75, 1,000, 600, 800	Open grazing	½, 1½, 1½, 1⅜		
	6.30 p. m.	2	75, 2,400	Bedded	⅜, 2⅜, 2¾, 2½	On old bed grounds	
Sept. 19	6.30 a. m.	2	75, 2,400	Leaving bed	0	do	
	12 m	3	75, 1,200, 1,200	Timber grazing	½, 1, 1¼		
	3.30 p. m.	3	75, 1,200, 1,200	do	¾, 1¼, 1¼		
	6.30 p. m.	2	2,400	Bedded	1, 2½, 2½	Bed ground, one in field	
Sept. 20	6.30 a. m.	2	75, 2,400	Leaving bed	0		
	2.30 p. m.	2	75, 2,490	Scattered grazing	½		
	6.30 p. m.	2	75, 2,400	Bedded	¾	One on bed ground, small herd could not be found.	
Sept. 21	7 a. m.	2	75, 2,400	Leaving bed ground	0	One on old bed ground, one in field	
	12 m	2	75, 2,400	Scattered grazing	¾		
	7 p. m.	2	75, 2,400	Bedded	1	One on bed ground, small band not found.	

TABLE 4.—*Action of sheep in coyote-proof pasture*—Continued.

[Pasture: 1,300 acres heavy timber, 400 acres open timber, and 860 acres glade area. Sheep: 750 old ewes and 1,713 yearlings.]

1	2	3	4	5	6	7	8
Date.	Time of day.	Number of bands.	Approximate number of sheep in each band.	How grazing.	Approximate distance grazed.	Where bedding.	Remarks.
					Miles.		
Sept. 22	7.15 a. m.	2	75, 2,400	Leaving bed	0	One on bed ground, small band not found.	
	10.30 a. m.	1	2,463	Timber grazing	¾, ½	Small band found and grazed in.	
	3 p. m	4	400, 1,000, 700, 300	Scattered grazing	¾, ½, ¾, 1		
	6.30 p. m.	1	2,463	Bedded	1⅜, 1⅛, 1⅛	On old bed ground	
Sept. 23	7.15 a. m.	1	2,463	Leaving bed	0	do	
	10 a. m	1	2,463	Scattered (1 mile grazing)	½		
	4 p. m	2	150, 2,300	do	½, ¾		
	5 p. m	4	150, 600, 700, 1,000	Scattered (glade grazing)	½, ½, ¾, ⅝		
	6.30 p. m.	2	150, 2,300	Bedded	⅝, ⅝, ¾, ⅝	One on bed ground, one not located.	
Sept. 24	7.15 a. m.	2	150, 2,300	Leaving bed	0		
	12.30 p. m.	3	150, 800, 1,500	Open grazing	½, ¾, 1¼		
	6.30 p. m.	3	150, 800, 1,500	Bedded	1, 1⅛	Two on old bed grounds, one not found.	
Sept. 25	7 a. m	3	150, 800, 1,500	Leaving bed	0		
	10 a. m	4	150, 200, 1,000, 1,100	Timber grazing	½, ¾, 1½, 1		
	6.30 p. m.	1	2,463	Bedded	1, 1¼, 1¾, 1¼	On bed ground	Grazed together by tender.
Sept. 26	7.15 a. m.	1	2,463	Leaving bed	0		
	11.30 a. m.	1	2,463	Open grazing (timber)	1½		
	3.30 p. m.	3	1,600, 400, 450	do	1⅞, 1½, 1⅞		
	7 p. m	2	2,000, 450	Bedded	2½, 2¼	One on bed ground, one not located.	
Sept. 27	7.15 a. m.	2	2,000, 450	Leaving bed	0		
	9.30 a. m.	3		Open grazing (timber)	¾, ¾, 1		
	11 a. m	1	2,463	do	1, 1, 1¼		
	12 m	2	1,500, 1,000	Trailing	2¼, 2¼		
	7.30 p. m.	1	2,463	Bedded	2¾, 2¾	On old bed ground	
Sept. 28	6.45 a. m.	1	2,463	Leaving bed	0		
	11.30 a. m.	1	2,463	Open grazing (glade)	1¼		
	3 p. m	2	1,500, 1,000	do	2¼, 2¼		
	6.30 p. m.	1	2,463	Bedded	3¼, 3¼	On old bed ground	
Sept. 29	7 a. m	1	2,463	Leaving bed	0		
	11 a. m	1	2,463	Open grazing (timber)	1½		
	2.30 p. m.	2	300, 2,150		2		
	4.30 p. m.	1	2,463	Bedded	2½	All at camp on Peavine	
Sept. 30	7.15 a. m.	1	2,463	Leaving bed	0	do	
	9.30 a. m.	2		Scattered grazing	½, 1½		
	11 a. m	1	2,463	do	¾, 1¾		
	5.30 p. m.	1	2,463	Bedded	1¼, 2¼	At camp on Peavine	

(*b*) Often within two hours after leaving the bed ground they would separate into four bunches and at a later hour the same day they would be in one or perhaps two bunches.

(*c*) Many times they would not separate until evening or not at all.

(*d*) Often they would separate in the morning and graze 2 miles apart and be together again before night.

(*e*) Not infrequently they would bed in two bunches at night, a mile or more apart, and be together again before midday following.

(*f*) Bunches that had been on different parts of the field for two days would meet on the third.

It is natural, then, to draw the conclusion that a band of sheep of this class, if allowed perfect freedom in an area free from destructive animals, and corresponding somewhat in size and topographic characteristics to the above area, will separate into bunches varying from 50 head to the entire number; that they may graze about, come together again, and again separate in any one day or part of a day; and further, that such action will continue day after day and week after week.

It seems necessary to limit the application of the data to areas corresponding in size and topographic features to the experimental pasture, because two points govern to some extent the separating into bunches. In open country the sheep may spread over an area one-fourth of a mile square and graze thus for hours without apparent division. Such a condition is much less probable in a timbered area. In this experiment in almost every instance separation for any length of time occurred in timbered areas.

2. *Open grazing.*—This feature is in part covered by the last discussion. The object was to determine the attitude of the sheep when free as compared with the closely bunched grazing so often practiced on timbered areas.

It is difficult to eliminate entirely the close grazing, because of the natural instinct and social habit of sheep. Any noise or disturbance whatever is a signal for them to mass for protection. Naturally, such massing necessitates close grazing for at least a short time until they can spread out again. The great difficulty with many herders is that, from fear of losing sheep, they are continually "rounding up" the herd, with more or less shouting or the use of dogs. The result is injury to both range and sheep.

The action of the sheep during the test was very satisfactory. They retained, more or less, the natural instinct to mass, but from the first day the tendency to open, scattered grazing, with little or no trailing, increased. At first they responded to every noise as though it were a herder's signal. Later the main band was not so ready to follow one frightened member. The feeling of suspicion and alarm gradually diminished, and only very seldom were they found grazing

in a close herd. The result was that the pastured area, though grazed close, was comparatively free from the worn paths usually so common on close-grazed ranges.

3. *Rambling about, and its effect.*—The great amount of grass trampled out by sheep is by no means due to the distance they travel in one day, and yet this question plays some part and deserves mention. Whether they travel a great deal or little is governed in part by the inherent nature of sheep and in part by the range grazed, atmospheric conditions, and disturbances.

Table 4 shows that on the first day of their freedom they traveled about as far as the pasture limits would permit. That was the case whenever they were transferred to a new area. The first day resulted in almost complete exploration.

Ordinarily sheep will travel much farther on open territory than in timber and very much farther on cool days than in hot weather. Very much, too, depends upon the condition of the range. Table 3 shows that the average daily distance traveled after September 20 was much greater than before that time. The early glade range began a new growth after the early fall rains. This growth was hardly sufficient to satisfy hunger, and yet it was so sought after by the sheep as to result in their grazing almost at a run, backward and forward, across glade areas. During this time, too, trailing was much greater than at any other time during the test. If sheep spread out, little damage is done to the range; if they trail in lines, one after another, the grass is killed unless it has good sod. In this experiment, even where the distance traveled was great, the amount of trailing was comparatively small.

4. *Do sheep bed in large bands when free?*—The solution of this question more than that of any other was interfered with by the presence of the coyote within the pasture and by the fact that grizzly bears could come in almost at will. However, by careful observation the natural tendency of the sheep could be ascertained.

Table 4 shows that the number of bunches bedded varied from 1 to 4, with from 75 to 2,463 head in each bunch. Moreover, the number of bunches after the sheep bedded was usually less than the number during the day, showing a tendency to collect for the night.

Partly from natural instinct and perhaps from customs of herding, sheep have a tendency to bed in bands, and the larger the band the more secure they feel. On several occasions the actions of small bands that had strayed away from the herd were observed. In each instance they were worried, uneasy, and excitable from nightfall until morning. Without any apparent disturbance they would mass together and shift ground many times during the night. Sometimes it was necessary to build a camp fire to quiet them. On the afternoon

of September 4 a bunch of about 100 head trailed out of the timber and galloped for a quarter of a mile in the direction the main herd had taken. The main band, however, had turned and gone in another direction and consequently were not located by the lost few. Meantime the frightened sheep had crossed the main road to the camp. They returned to this road, and, although it was only 4 o'clock and there were much better bed grounds near by, they stayed at the road the remainder of the afternoon and all night. Many other similar instances might be cited. Moreover, whenever a small band was near a range which they knew, they would invariably go to the old bed ground. This was in part due to a desire for an old ground, but more from instinct and social habit. One small band, which had been lost for two days, was found following a belled horse in a remote part of the pasture. It may be that this tendency will be overcome in a longer period of time with absolute freedom from disturbance. The change during the month of test was very slight.

5. *To what extent do sheep seek the same bed ground night after night?*—The question concerning the return of sheep to the same bed ground each night is in part answered by column 7 of Table 4. This shows that in most cases the sheep bedded on one or another of four old bed grounds within the pasture. As already stated, whenever they were in a locality known to them they invariably sought an old bed ground for the night. Occasionally a band would stray off into a new area and night would overtake them there. In such event they would always choose an open area. They will not bed in the timber unless they are unable to get out.

This tendency of sheep always to seek an old bed ground is natural, as it is with other domestic animals. Cattle, whenever possible, will choose a common bed ground near an old cabin or corral.

SUMMARY.

In brief it may be said, then, that when entirely protected from destructive animals a band of dry sheep will separate into bunches, perhaps come together again, and again separate while grazing; that they will graze much more openly and do much less trailing than when they are herded; that they may travel as far or farther in one day than when herded, but the movement is much less injurious to the forage crop, because they pass over an area only once and are then scattered so that only one animal strikes a plant, whereas when herded they may pass backward and forward over an area many times, and perhaps as many as fifty sheep may strike one plant; that their natural tendency is to bed at night in bands, but in smaller bands than when herded; that they much prefer a bed ground that has often been used to one that is entirely new.

EFFECTS OF THE SYSTEM ON THE FORAGE PLANTS AND CARRYING CAPACITY OF RANGE.

To be of practical value, a discussion of the influence of the pasture system on the range must include a comparative statement of effects under this system and under that of herding; also, it would call for a comparative statement of carrying capacity under the two systems of grazing. Owing to the difficulties and delays in construction work the past season, it was impossible to accumulate the actual experimental data of this kind necessary for conclusive statements.

It was expected that the construction work would be completed and the inclosure ready for use not later than July 22. The fact that it was not necessitated some provision for grazing the experimental herd. There was no area unoccupied on the forest, and it was necessary to allow the band to graze such portions of the proposed pasture as would least interfere with the experimental work after the inclosure was completed. With this understanding the herd reached Billy Meadows July 26.

The southwest section, containing most of the early glade range was allotted for grazing, with the camp on the Peavine, at the east side of the allotment. The sheep remained at this camp and grazed the one section until August 17. They were then allowed to graze the southeast section until August 21. On that date they were moved to the northwest section, with the camp on the Peavine, where they grazed until turned loose September 3.

Aside from this grazing, the area supported 20 horses, on an average, for three months. This makes the grazing record on the 2,560 acres as follows: Sheep herded for 38 days, 2,495 head; sheep pastured for 30 days, 2,463 head; horses grazed for 90 days, 20 head.

Thus, practically only one-third the grazing was done under the experimental system. It is hoped that the necessary data on the effect of each system will be collected during the season of 1908.

It may safely be said, however, that the above acreage per head for grazing is much less than any allotment grazing on corresponding areas where sheep are herded. The minimum under such permits may safely be placed at 2 acres per head, and varies from that to 10 acres per head. The range thus grazed was in some instances left in worse condition than the pasture area; other sections were less closely grazed. This variation was in part due to difference in water facilities, but to a greater extent to methods of herding.

That the experimental system will materially increase the carrying capacity of the range is not to be doubted; that the observations thus far recorded point to this fact is evident from the action of sheep. Just what the amount of increase in carrying capacity will be has not yet been ascertained.

Approved:

JAMES WILSON, *Secretary.*

WASHINGTON, D. C., *September 1, 1908.*

[Cir. 156]